A BIOLOGICAL ASSESSMENT OF SITES IN THE BITTERROOT RIVER DRAINAGE: RAVALLI COUNTY, MONTANA
Project TMDL - C05

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A report to

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by

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INTRODUCTION

Aquatic invertebrates are aptly applied to bioassessment since they are known to be important indicators of stream ecosystem health (Hynes 1970). Long lives, complex life cycles and limited mobility mean that there is ample time for the benthic community to respond to cumulative effects of environmental perturbations.

This report summarizes data collected in October 2002 from sites in the West and East Forks of the Bitterroot River drainage in Ravalli County, Montana. Aquatic invertebrate assemblages were sampled by personnel of the Montana Department of Environmental Quality (MT DEQ). All of the study sites lie within the Northern Rockies ecoregion (Woods et al. 1999).

A multimetric approach to bioassessment such as the one applied in this study uses attributes of the assemblage in an integrated way to measure biotic health. A stream with good biotic health is "...a balanced, integrated, adaptive system having the full range of elements and processes that are expected in the region's natural environment..." (Karr and Chu 1999). The approach designed by Plafkin et al. (1989) and adapted for use in the State of Montana has been defined as "... an array of measures or metrics that individually provide information on diverse biological attributes, and when integrated, provide an overall indication of biological condition." (Barbour et al. 1995). Community attributes that can contribute meaningfully to interpretation of benthic data include assemblage structure, sensitivity of community members to stress or pollution, and functional traits. Each metric component contributes an independent measure of the biotic integrity of a stream site; combining the components into a total score reduces variance and increases precision of the assessment (Fore et al. 1996). Effectiveness of the integrated metrics depends on the applicability of the underlying model, which rests on a foundation of three essential elements (Bollman 1998a). The first of these is an appropriate stratification or classification of stream sites, typically, by ecoregion. Second, metrics must be selected based upon their ability to accurately express biological condition. Third, an adequate assessment of habitat conditions at each site to be studied enhances the interpretation of metric outcomes.

Implicit in the multimetric method and its associated habitat assessment is an assumption of correlative relationships between habitat measures and the biotic metrics, in the absence of water quality impairment. These relationships may vary regionally, requiring an examination of habitat assessment elements and biotic metrics and a test of the presumed relationship between them. Bollman (1998a) has recently studied the assemblages of the Montana Valleys and Foothill Prairies ecoregion, and has recommended a battery of metrics applicable to the montane ecoregions of western Montana. This metric battery has been shown to be sensitive to impairment, related to measures of habitat integrity, and consistent over replicated samples.

METHODS

Samples were collected in October 2002 by MT DEQ and Land and Water Consulting personnel. Sample designations and site locations are indicated in Table 1. The site selection and sampling method employed were those recommended in the MT DEQ Standard Operating Procedures for Aquatic Macroinvertebrate Sampling (Bukantis 1998). Aquatic invertebrate samples were delivered to Rhithron Associates, Inc., Missoula, Montana, for laboratory and data analyses.

In the laboratory, the MT DEQ-recommended sorting method was used to obtain subsamples of at least 300 organisms from each sample, when possible. Organisms were identified to the lowest possible taxonomic levels consistent with MT DEQ protocols.

Table 1. Sample designations and locations. Sites are listed by drainage in upstream-to-downstream order. West and East Forks of the Bitterroot River, October 2002.

Site	Sampling Date	Station ID	Activity ID	Location Description	Latitude/ Longitude
West Fork Bitterroot River Drainage					
Deer	10-08-02	C05DEERC01	02-CL422-M	Deer Creek	45°35'34"/114°19'29"
UOver1	10-09-02	C05OVWHC01	02-CL423-M	Overwhich Creek – Upper	46°40'17"/114°18'11"
LOver2	10-09-02	C05OVWHC02	02-CL424-M	Overwhich Creek – Lower	45°39'12"/114°13'9"
Ditch	10-08-02	C05DITCC01	02-CL421-M	Ditch Creek	45°45'3"/114°16'31"
Buck	10-09-02	C05BUCKC01	02-CL431-M	Buck Creek	45°46'59"/114°15'41"
UNez1	10-10-02	C05NEZPF01	02-CL432-M	Nez Perce Fork – Upper	45°43'50"/114°28'47"
MNez2	10-10-02	C05NEZPF02	02-CL433-M	Nez Perce – Middle	45°45'12"/114°22'19"
LNez3	10-10-02	C05NEZPF03	02-CL434-M	Nez Perce – Lower	45°48'6"/114°16'15"
East Fork Bitterroot River Drainage					
Mart1	10-09-02	C05MARTC01	02-C255-M	Martin Creek	45°57'4"/113°44' 37"
Mart2	10-09-02	C05MARTC02	02-C256-M	Martin Creek 100 yds above the mouth (Moose Cr)	45°55'54"/113°43'23"
Mead1	10-08-02	C05MEDWC01	02-C253-M	Meadow Creek above Spruce Creek	45°50'31"/113°49'9"
Mead2	10-09-02	C05MEDWC02	02-C254-M	Meadow Creek upstream from mouth of EF Bitterroot	45°54'25"/113°46'49"
Reim1	10-10-02	C05REMLC01	02-C257-M	Reimel Creek .25 mi upstream of Wallace Creek	45°47'40"/113°55'38"
Reim2	10-10-02	C05REMLC02	02-C258-M	Reimel Creek	45°49'22"/113°56'29"

To assess aquatic invertebrate communities in this study, a multimetric index developed in previous work for streams of western Montana ecoregions (Bollman 1998a) was used. Multimetric indices result in a single numeric score, which integrates the values of several individual indicators of biologic health. Each metric used in this index was tested for its response or sensitivity to varying degrees of human influence. Correlations have been demonstrated between the metrics and various symptoms of human-caused impairment as expressed in water quality parameters or instream, streambank and stream reach morphologic features. Metrics were screened to minimize variability over natural environmental gradients, such as site elevation or sampling season, which might confound interpretation of results (Bollman 1998a). The multimetric index used in this report incorporates multiple attributes of the sampled assemblage into an integrated score that accurately describes the benthic community of each site in terms of its biologic integrity. In addition to the metrics comprising the index, other metrics shown to be applicable to biomonitoring in other regions (Kleindl 1995, Patterson 1996, Rossano 1995) were used for descriptive interpretation of results. These metrics include the number of "clinger" taxa, long-lived taxa richness, the percent of predatory organisms, and others. They are not included in the integrated bioassessment score, however, since their performance in western Montana ecoregions is unknown. However, the relationship of these metrics to habitat conditions is intuitive and reasonable.

The six metrics comprising the bioassessment index used in this study were selected because, both individually and as an integrated metric battery, they are robust at distinguishing impaired sites from relatively unimpaired sites (Bollman 1998a). In addition, they are relevant to the kinds of impacts that are present in the Bitterroot River drainage. They have been demonstrated to be more variable with anthropogenic disturbance than with natural environmental gradients (Bollman 1998a). Each of the six metrics developed and tested for western Montana ecoregions is described below.

1. **Ephemeroptera (mayfly) taxa richness.** The number of mayfly taxa declines as water quality diminishes. Impairments to water quality which have been demonstrated to adversely affect the ability of mayflies to flourish include elevated water temperatures, heavy metal contamination, increased turbidity, low or high pH, elevated specific conductance and toxic chemicals. Few mayfly species are able to tolerate certain disturbances to instream habitat, such as excessive sediment deposition.
2. **Plecoptera (stonefly) taxa richness.** Stoneflies are particularly susceptible to impairments that affect a stream on a reach-level scale, such as loss of riparian canopy, streambank instability, channelization, and alteration of morphological features such as pool frequency and function, riffle development and sinuosity. Just as all benthic organisms, they are also susceptible to smaller scale habitat loss, such as by sediment deposition, loss of interstitial spaces between substrate particles, or unstable substrate.
3. **Trichoptera (caddisfly) taxa richness.** Caddisfly taxa richness has been shown to decline when sediment deposition affects their habitat. In addition, the presence of certain case-building caddisflies can indicate good retention of woody debris and lack of scouring flow conditions.
4. **Number of sensitive taxa.** Sensitive taxa are generally the first to disappear as anthropogenic disturbances increase. The list of sensitive taxa used here includes organisms sensitive to a wide range of disturbances, including warmer water temperatures, organic or nutrient pollution, toxic pollution, sediment deposition, substrate instability and others. Unimpaired streams of western Montana typically support at least four sensitive taxa (Bollman 1998a).
5. **Percent filter feeders.** Filter-feeding organisms are a diverse group; they capture small particles of organic matter, or organically enriched sediment material, from the water column by means of a variety of adaptations, such as silken nets or hairy appendages. In forested montane streams, filterers are expected to occur in insignificant numbers. Their abundance increases when canopy cover is lost and when water temperatures increase and the accompanying growth of filamentous algae occurs. Some

filtering organisms, specifically the Arctopsychid caddisflies (*Arctopsyche* sp. and *Parapsyche* spp.) build silken nets with large mesh sizes that capture small organisms such as chironomids and early-instar mayflies. Here they are considered predators, and, in this study, their abundance does not contribute to the percent filter feeders metric.

6. Percent tolerant taxa. Tolerant taxa are ubiquitous in stream sites, but when disturbance increases, their abundance increases proportionately. The list of taxa used here includes organisms tolerant of a wide range of disturbances, including warmer water temperatures, organic or nutrient pollution, toxic pollution, sediment deposition, substrate instability and others.

Scoring criteria for each of the six metrics are presented in Table 2. Metrics differ in their possible value ranges as well as in the direction the values move as biological conditions change. For example, Ephemeroptera richness values may range from zero to ten taxa or higher. Larger values generally indicate favorable biotic conditions. On the other hand, the percent filterers metric may range from 0% to 100%; in this case, larger values are negative indicators of biotic health. To facilitate scoring, therefore, metric values were transformed into a single scale. The range of each metric has been divided into four parts and assigned a point score between zero and three. A score of three indicates a metric value similar to one characteristic of a non-impaired condition. A score of zero indicates strong deviation from non-impaired condition and suggests severe degradation of biotic health. Scores for each metric were summed to give an overall score, the total bioassessment score, for each site in each sampling event. These scores were expressed as the percent of the maximum possible score, which is 18 for this metric battery.

Table 2. Metrics and scoring criteria for bioassessment of streams of western Montana ecoregions (Bollman 1998a).

	Score			
Metric	**3**	**2**	**1**	**0**
Ephemeroptera taxa richness	> 5	5 - 4	3 – 2	< 2
Plecoptera taxa richness	> 3	3 - 2	1	0
Trichoptera taxa richness	> 4	4 - 3	2	< 2
Sensitive taxa richness	> 3	3 - 2	1	0
Percent filterers	0 – 5	5.01 - 10	10.01 – 25	> 25
Percent tolerant taxa	0 – 5	5.01 - 10	10.01 – 35	> 35

The total bioassessment score for each site was expressed in terms of use-support. Criteria for use-support designations were developed by MT DEQ and are presented in Table 3a. Scores were also translated into impairment classifications according to criteria outlined in Table 3b.

Table 3a. Criteria for the assignment of use-support classifications / standards violation thresholds (Bukantis 1998).	
% Comparability to reference	Use support
>75	Full support--standards not violated
25-75	Partial support--moderate impairment--standards violated
<25	Non-support--severe impairment--standards violated

Table 3b. Criteria for the assignment of impairment classifications (Plafkin et al. 1989).	
% Comparability to reference	Classification
> 83	nonimpaired
54-79	slightly impaired
21-50	moderately impaired
<17	severely impaired

In this report, certain other metrics were used as descriptors of the benthic community response to habitat or water quality but were not incorporated into the bioassessment metric battery, either because they have not yet been tested for reliability in streams of western Montana, or because results of such testing did not show them to be robust at distinguishing impairment, or because they did not meet other requirements for inclusion in the metric battery. These metrics and their use in predicting the causes of impairment or in describing its effects on the biotic community are described below.

- The modified biotic index. This metric is an adaptation of the Hilsenhoff Biotic Index (HBI, Hilsenhoff 1987), which was originally designed to indicate organic enrichment of waters. Values of this metric are lowest in least impacted conditions. Taxa tolerant to saprobic conditions are also generally tolerant of warm water, fine sediment and heavy filamentous algae growth (Bollman 1998b). Loss of canopy cover is often a contributor to higher biotic index values. The taxa values used in this report are modified to reflect habitat and water quality conditions in Montana (Bukantis 1998). Ordination studies of the benthic fauna of Montana's foothill prairie streams showed that there is a correlation between modified biotic index values and water temperature, substrate embeddedness, and fine sediment (Bollman 1998a). In a study of reference streams, the average value of the modified biotic index in least-impaired streams of western Montana was 2.5 (Wisseman 1992).
- Taxa richness. This metric is a simple count of the number of unique taxa present in a sample. Average taxa richness in samples from reference streams in western Montana was 28 (Wisseman 1992). Taxa richness is an expression of biodiversity, and generally decreases with degraded habitat or diminished water quality. However, taxa richness may show a paradoxical increase when mild nutrient enrichment occurs in previously oligotrophic waters, so this metric must be interpreted with caution.
- Percent predators. Aquatic invertebrate predators depend on a reliable source of invertebrate prey, and their abundance provides a measure of the trophic complexity supported by a site. Less disturbed sites have more plentiful habitat niches to support diverse prey species, which in turn support abundant predator species.

- Number of "clinger" taxa. So-called "clinger" taxa have physical adaptations that allow them to cling to smooth substrates in rapidly flowing water. Aquatic invertebrate "clingers" are sensitive to fine sediments that fill interstices between substrate particles and eliminate habitat complexity. Animals that occupy the hyporheic zones are included in this group of taxa. Expected "clinger" taxa richness in unimpaired streams of western Montana is at least 14 (Bollman 1998b).
- Number of long-lived taxa. Long-lived or semivoltine taxa require more than a year to completely develop, and their numbers decline when habitat and/or water quality conditions are unstable. They may completely disappear if channels are dewatered or if there are periodic water temperature elevations or other interruptions to their life cycles. Western Montana streams with stable habitat conditions are expected to support six or more long-lived taxa (Bollman 1998b).

RESULTS

Habitat Assessment

Tables 4a and 4b show the habitat parameters evaluated, parameter scores and overall habitat evaluations for the 14 sites studied. Figure 1 graphically compares total habitat assessment scores for these sites. Overall habitat conditions generally received positive evaluations; all sites studied were categorized as optimal or sub-optimal.

West Fork Bitterroot River drainage

Overall habitat conditions were judged optimal at the Deer Creek site. All instream parameters received maximal scores. Streambank and riparian zone measures were appraised as sub-optimal.

On Overwhich Creek, the upper site (UOver1) appeared to have excellent instream habitat, channel morphology, and streambank integrity. The riparian zone was abbreviated on one side of the channel due to an old roadbed. At the lower site (LOver2), however, reduction of riparian vegetation due to residential development affected the riparian zone width and streambank vegetation. Streambanks were judged moderately unstable on one side of the stream; some stabilization efforts were noted, but field notes report evidence of persisting erosion. Instream habitat was judged to be affected by fine sediment deposition; however, scores imply that benthic substrate diversity was thought to be only minimally affected. Overall conditions were rated sub-optimal.

Optimal habitat conditions were noted at the site on Ditch Creek, despite the appraisal of embedded substrate particles. Benthic substrate diversity was judged sub-optimal, and flow conditions were apparently not as good as expected. Other instream, channel, streambank, and riparian measures were scored optimally.

Monotonous benthic substrate was observed at the site on Buck Creek, and substrate particles appeared to be embedded. In addition, some limitation to the extent of the riparian zone was noted. All other instream, streambank, and channel parameters were judged essentially unimpaired, so that despite the perception of sub-optimal or marginal substrate condition, the total habitat assessment score indicated optimal overall conditions.

All habitat assessment parameters were judged optimal at the upper site on Nez Perce Creek (UNez1), and there were no field notations suggesting that anything other than near-pristine conditions were observed. Farther downstream, however, at the middle site (MNez2), channel alterations related to a road were noted. Streambanks on one side were perceived to be moderately stable, and vegetative protection of the opposite streambank was appraised as marginal. Some abbreviation of the riparian zone width was also reported. The total score still resulted in an optimal rating for overall habitat conditions at this site. At the lowermost site on Nez Perce Creek (LNez3), channel alterations were reported; these were apparently attributable to a constructed dike. Streambanks were judged to be only moderately stable, with disruption

to vegetative protection evident. Riparian zone width was perceived to be abbreviated. Overall habitat conditions at this site were rated sub-optimal.

East Fork Bitterroot River drainage

Some embeddedness of substrate particles was noted at the upper site on Martin Creek (Mart1), but other habitat parameters were perceived to be in optimal condition. Total habitat assessment score suggested optimal overall conditions here, as well as at the lower site (Mart2), where all parameters received optimal scores.

Total habitat assessment scores indicated optimal conditions at both sites on Meadow Creek. At the upper site (Mead1), field notes report that substrate particles were fairly highly embedded by fines. Fine sediment deposition was noted in pools and at water's edge. Embeddedness was also a notable finding at the lower site (Mead2), but scores suggest that sediment deposits were judged to be less of an issue here than at the upstream site. Substrate diversity, streambank measures, channel morphology, and riparian zone width were perceived to be in optimal condition at both Meadow Creek sites.

The upper site on Reimel Creek (Reim1) was reported to have suffered apparent damage in the aftermath of recent forest fires. A "recent substantial increase in sediment load" was reported, resulting in moderate deposition of sediment, and some embeddedness of substrate particles. Field notes further suggest that high shear stress due to increased water yield apparently has caused severe destabilization of streambanks; both sides of the channel were judged to have been affected. Bank vegetative protection appeared to be disrupted. Other parameters relating to channel morphology, flow status, and riparian zone integrity were assigned optimal scores; the overall habitat condition at this site scored sub-optimally. At the lower site (Reim2), optimal conditions were reported, despite indications in the field notes that the area burned in 2000. Grazing pressure apparently combined with the effects of the fire to produce some disruption of streambank vegetative protection. Still, the overall habitat score suggested optimal conditions at this site.

Table 4a. Stream and riparian habitat assessment. The eight West Fork Bitterroot sites were assessed based upon criteria developed by MT DEQ for streams with riffle/run prevalence. Bitterroot River Drainage, October 2002.

Max. possible score	**Parameter**	**Deer**	**UOver1**	**LOver2**	**Ditch**	**Buck**	**UNez1**	**MNez2**	**LNez3**
10	Riffle development	10	10	8	10	9	10	8	8
10	Benthic substrate	10	10	9	8	5	10	9	8
20	Embeddedness	20	20	18	15	15	20	20	16
20	Channel alteration	20	20	11	20	18	20	14	11
20	Sediment deposition	20	20	12	20	17	20	16	16
20	Channel flow status	20	20	16	15	18	20	17	16
20	Bank stability	8 / 8	10 / 10	5 / 3	10 / 10	10 / 10	10 / 10	9 / 8	8 / 8
20	Bank vegetation	9 / 9	10 / 10	6 / 4	10 / 10	9 / 9	10 / 10	5 / 8	8 / 8
20	Vegetated zone	7 / 8	10 / 7	6 / 6	10 / 10	8 / 8	10 / 10	6 / 8	8 / 8
160	Total	149	157	104	148	136	160	128	123
	Percent of maximum	**93%**	**98%**	**65%**	**92%**	**85%**	**100%**	**80%**	**77%**
	CONDITION*	**Optimal**	**Optimal**	**Sub-optimal**	**Optimal**	**Optimal**	**Optimal**	**Optimal**	**Sub-optimal**

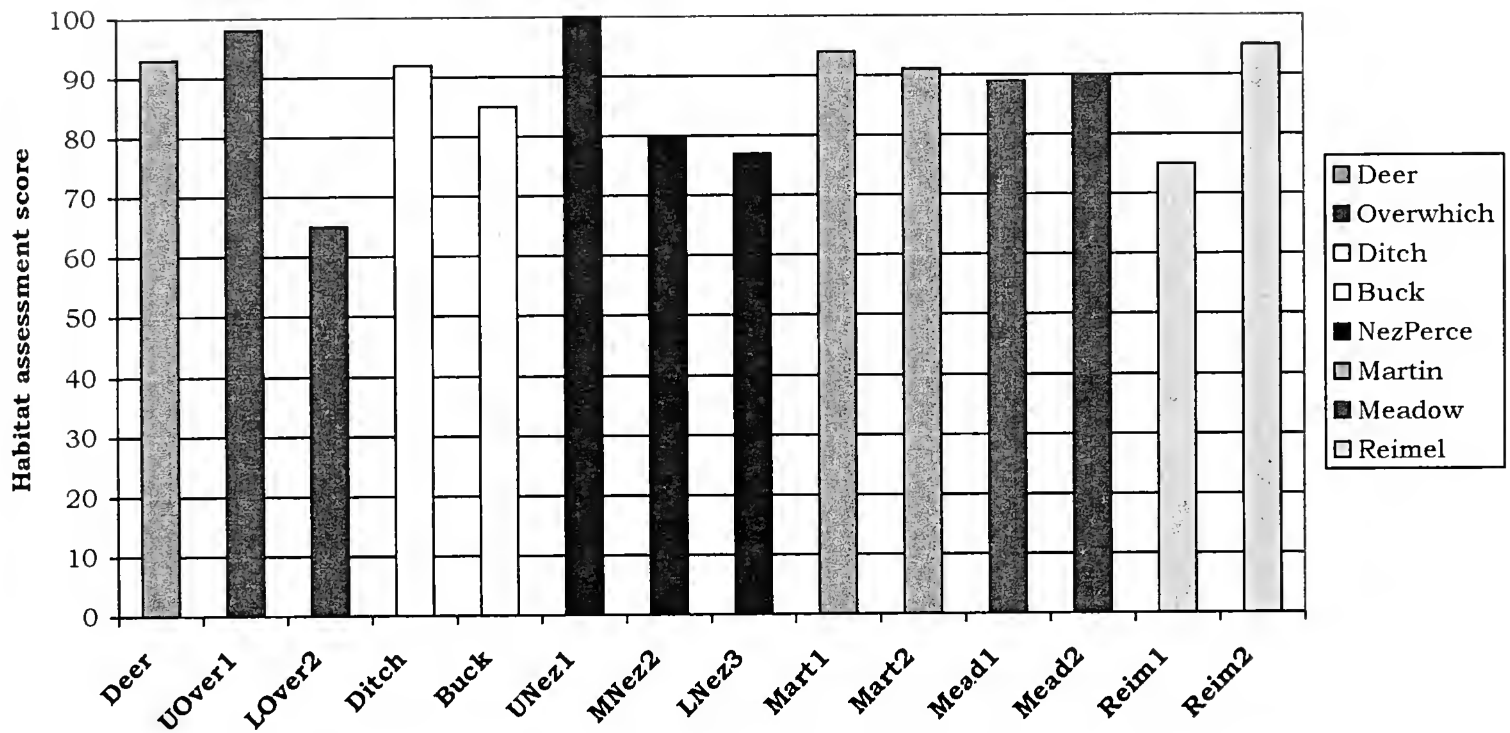
Condition categories: Optimal > 80% of maximum score; Sub-optimal 75 - 56%; Marginal 49 - 29%; Poor <23%. (Plafkin et al. 1989).

Table 4b. Stream and riparian habitat assessment. Five of the East Fork Bitterroot sites were assessed based upon criteria developed by MT DEQ for streams with riffle/run prevalence, while the assessments for the sixth site, Reim2, was based upon criteria developed for streams with glide/pool prevalence. Bitterroot River Drainage, October 2002.

Max. possible score	Parameter	**Mart1**	**Mart2**	**Mead1**	**Mead2**	**Reim1**	**Max. possible score**	**Parameter**	**Reim2**
10	Riffle development	8	10	10	10	10	20	Bottom substrate	20
10	Benthic substrate	10	10	10	10	9	20	Pool substrate char.	20
20	Embeddedness	15	10	11	8	15	20	Pool variability	18
20	Channel alteration	20	20	19	20	20	20	Channel alteration	20
20	Sediment deposition	18	18	15	16	6	20	Sediment deposition	20
20	Channel flow status	20	20	20	20	20	20	Channel sinuosity	16
20	Bank stability	10 / 10	10 / 10	9 / 9	10 / 10	2 / 2	20	Channel flow status	20
20	Bank vegetation	10 / 10	9 / 9	10 / 10	10 / 10	8 / 8	20	Bank vegetation	8 / 8
20	Vegetated zone	10 / 10	10 / 10	10 / 10	10 / 10	10 / 10	20	Bank stability	10 / 10
160	Total	151	146	143	144	120	20	Vegetated zone	10 / 10
							200	Total	190
	Percent of maximum	**94%**	**91%**	**89%**	**90%**	**75%**		Percent of maximum	**95%**
	CONDITION*	**Optimal**	**Optimal**	**Optimal**	**Optimal**	**Sub-optimal**		CONDITION*	**Optimal**

* Condition categories: Optimal > 80% of maximum score; Sub-optimal 75 - 56%; Marginal 49 - 29%; Poor <23%. (Plafkin et al. 1989.)

Figure 1. Total habitat assessment compared among sites in the Bitterroot River Drainage, October 2002. Scores are reported as the percent of maximum possible score.



Bioassessment

Figure 2 summarizes bioassessment scores for aquatic invertebrate communities sampled at the 14 sites in this study. Tables 5a and 5b itemizes each contributing metric and shows individual metric scores for each site. Tables 3a and 3b above show criteria for use-support categories recommended by MT DEQ (Bukantis 1998) and impairment classifications (Plafkin et al. 1989). Macroinvertebrate taxa lists, metric results and other information for each sample are given in the Appendix.

Applying these bioassessment methods to the data gives results that suggest that these watersheds of the West and East Fork of the Bitterroot River support sensitive benthic assemblages with taxonomic and functional characteristics expected of near-pristine streams in montane or foothill environments. Scores indicate that all sites fully support designated uses, and are essentially unimpaired. Scores ranged from 89% of maximum to 100% of maximum.

Aquatic invertebrate communities

Interpretations of biotic integrity in this report are made without reference to results of habitat assessments, or any other information about the sites or watersheds that may have accompanied the invertebrate samples. Interpretations are based entirely on: the taxonomic and functional composition of the sampled invertebrate assemblages; the sensitivities, tolerances, physiology, and habitus information for individual taxa gleaned from the writer's research; the published literature, and other expert sources; and on the performance of bioassessment metrics, described earlier in the report, which have been demonstrated to be useful tools for interpreting potential implications of benthic invertebrate assemblage composition.

West Fork Bitterroot River drainage

Low biotic index value (2.19) and high mayfly taxa richness (8) suggest that water quality was excellent at the sampled site on Deer Creek. Eight sensitive cold-stenotherm taxa, including the mayfly *Caudatella hystrix* and the caddisfly *Dolophilodes* sp. were collected. It appears likely that cold, clean water was a characteristic of the site.

Habitat indicators suggested undisrupted habitat on both large and small scales. Twenty-one "clinger" taxa and 7 caddisfly taxa were represented in the sample; these groups are associated with hard substrates clean of fine substrate deposition. High taxa richness (36) and a large contingent of predators (11 taxa) suggest that instream habitats were complex. Six stonefly taxa were present at the site; this degree of diversity among the stoneflies may indicate that reach-scale habitat features were essentially intact. Such features could include riparian zone integrity, streambank stability, and natural channel morphology. Long-lived taxa were amply represented, implying that year-round surface flow had probably not been recently interrupted by dewatering, nor had other catastrophic life-cycle limiting events occurred. All expected functional components of a montane assemblage were present in suitable proportions.

On Overwhich Creek, the upper site (UOver1) supported a sensitive, cold-water benthic assemblage characteristic of unimpaired montane streams. Eight mayfly taxa were collected, and the entire assemblage yielded a biotic index value (1.50) suggestive of oligotrophic conditions. Twelve taxa found in the sample are exclusively cold water inhabitants.

Reach-scale habitat features were probably essentially undisturbed here, since the stonefly fauna was rich and diverse; no fewer than 10 taxa were present at the site, and these included the sensitive perlid *Doroneuria* sp. and the equally intolerant perlodid *Megarcys* sp. Smaller-scale features also appeared to be in near-pristine condition. Taxa richness was high (41 taxa) and predators composed a considerable portion (27%, 14 taxa) of both the functional and the taxonomic make-up of the assemblage. These findings imply plentiful and diverse instream habitats. Twenty "clinger" taxa and 9 caddisfly taxa were collected, strongly suggesting that fine sediment deposition did not appreciably alter hard substrate surfaces. Six

Figure 2. Total bioassessment scores compared among sites in the Bitterroot River Drainage, October 2002. The revised Montana bioassessment method (Bollman 1998) was used to determine scores. Scores are reported as the percent of maximum possible score.

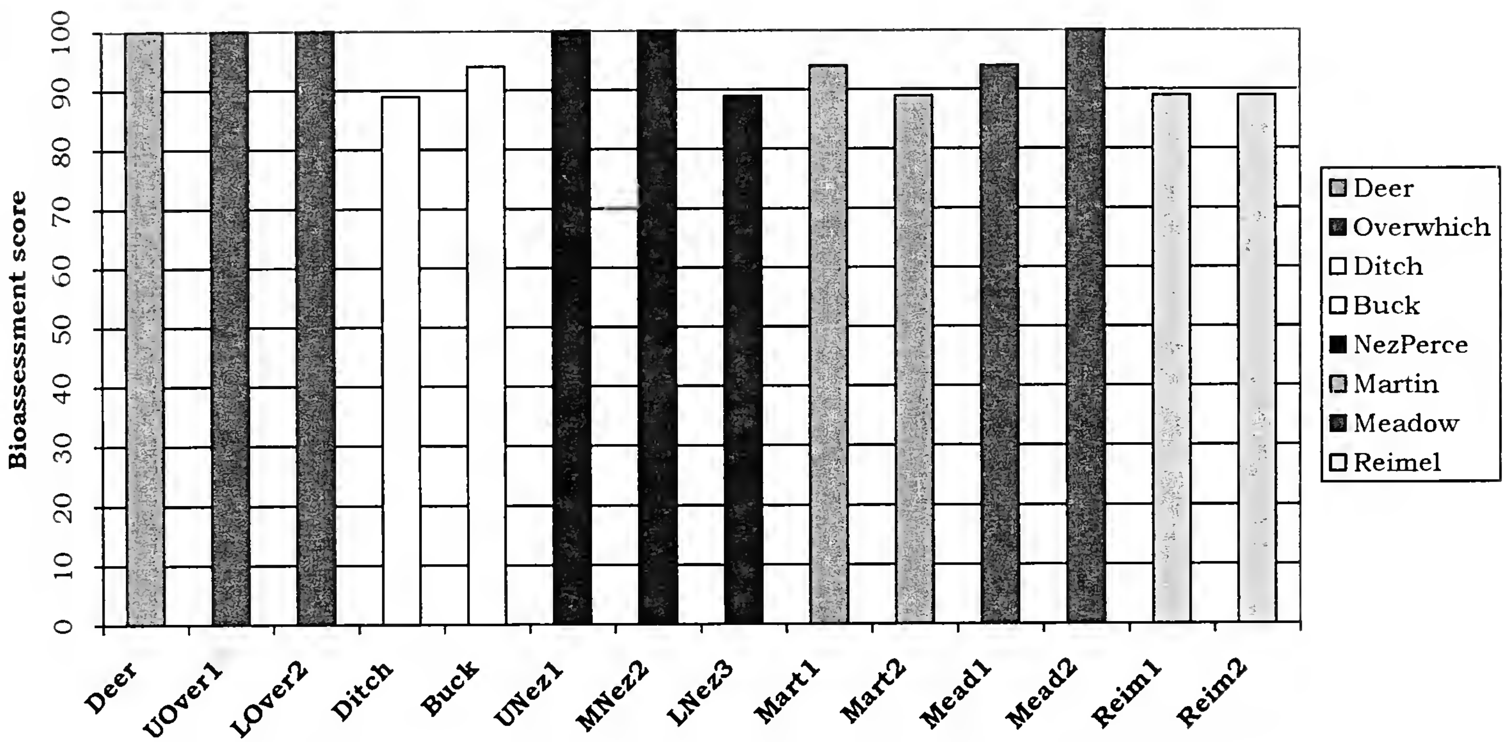


Table 5a. Metric values, scores, and bioassessments for sites in the West Fork Bitterroot River Drainage, October 2000. Site locations are given in Table 1.

	SITES							
	Deer	**UOver1**	**LOver2**	**Ditch**	**Buck**	**UNez1**	**MNez2**	**LNez3**
METRICS	**METRIC VALUES**							
Ephemeroptera richness	8	8	11	3	5	9	10	7
Plecoptera richness	6	9	8	6	5	8	8	9
Trichoptera richness	7	9	11	6	8	11	7	6
Number of sensitive taxa	8	12	13	5	8	15	10	5
Percent filterers	1.52	2.69	1.69	0	2.36	0	2.20	4.76
Percent tolerant taxa	1.77	0.34	3.05	0.35	0	0.32	0.83	10.20
	METRIC SCORES							
Ephemeroptera richness	3	3	3	1	2	3	3	3
Plecoptera richness	3	3	3	3	3	3	3	3
Trichoptera richness	3	3	3	3	3	3	3	3
Number of sensitive taxa	3	3	3	3	3	3	3	3
Percent filterers	3	3	3	3	3	3	3	3
Percent tolerant taxa	3	3	3	3	3	3	3	1
TOTAL SCORE (max.=18)	18	18	18	16	17	18	18	16
PERCENT OF MAX.	**100%**	**100%**	**100%**	**89%**	**94%**	**100%**	**100%**	**89%**
Impairment classification*	**NON**	**NON**	**NON**	**NON**	**NON**	**NON**	**NON**	**NON**
USE SUPPORT †	**FULL**	**FULL**	**FULL**	**FULL**	**FULL**	**FULL**	**FULL**	**FULL**

* Classifications: (NON) non-impaired, (SLI) slightly impaired, (MOD) moderately impaired, (SEV) severely impaired. See Table 3b.
† Use support designations: See Table 3a.

Table 5b. Metric values, scores, and bioassessments for sites in the East Fork Bitterroot River Drainage, October 2000. Site locations are given in Table 1.

	SITES					
METRICS	**Mart1**	**Mart2**	**Mead1**	**Mead2**	**Reim1**	**Reim2**
			METRIC VALUES			
Ephemeroptera richness	9	8	10	9	11	9
Plecoptera richness	7	7	7	7	6	6
Trichoptera richness	9	4	10	7	8	8
Number of sensitive taxa	9	5	16	6	11	8
Percent filterers	4.38	2.99	5.77	4.19	9.26	11.28
Percent tolerant taxa	6.25	5.65	0	1.94	8.33	3.35
			METRIC SCORES			
Ephemeroptera richness	3	3	3	3	3	3
Plecoptera richness	3	3	3	3	3	3
Trichoptera richness	3	2	3	3	3	3
Number of sensitive taxa	3	3	3	3	3	3
Percent filterers	3	3	2	3	2	1
Percent tolerant taxa	2	2	3	3	2	3
TOTAL SCORE (max.=18)	17	16	17	18	16	16
PERCENT OF MAX.	**94%**	**89%**	**94%**	**100%**	**89%**	**89%**
Impairment classification*	**NON**	**NON**	**NON**	**NON**	**NON**	**NON**
USE SUPPORT †	**FULL**	**FULL**	**FULL**	**FULL**	**FULL**	**FULL**

* Classifications: (NON) non-impaired, (SLI) slightly impaired, (MOD) moderately impaired, (SEV) severely impaired. See Table 3b.
† Use support designations: See Table 3a.

long-lived taxa were present; this is fewer than expected, but the group accounted for 24% of sampled animals and included several perlid stoneflies and the caddisfly *Arctopsyche grandis*. Dewatering or other catastrophes had apparently not recently limited long life cycles in this reach. The functional mix was composed of all expected elements in appropriate proportions.

Excellent water and habitat quality persisted downstream at the lower sampled site on Overwhich Creek (LOver2). Here the calculated biotic index value was 1.82, and 11 mayfly taxa were present in the sample. Of the 44 taxa collected, 13 were cold-stenotherms, including the caddisfly *Apatania* sp. and the mayfly *Drunella doddsi*. These findings strongly imply cold water unpolluted by nutrients or toxics.

A rich and diverse fauna with 15 predator taxa represented suggests that instream habitats were also diverse as well as being abundantly available. Among those available habitats were hard substrate surfaces free from fine sediments; evidence for this includes the presence of a very large number of "clinger" taxa (23) along with high caddisfly taxa richness (11). Although only 5 long-lived taxa were collected, it seems likely that dewatering or other profound limitations to semivoltine life cycles had not recently occurred, since these taxa included perlid stoneflies and retreat-building caddisflies and other stable inhabitants. In addition, the 5 long-lived taxa comprised 15% of sampled animals. The functional mix included all expected components in expected abundances.

Only 3 mayfly taxa were present in the sample collected at the Ditch Creek site, suggesting that water quality may have been impaired. However, the biotic index value calculated for the overall assemblage was 2.23, within expected limits for a montane stream. Among the collected animals were 5 sensitive cold-stenotherm taxa, including the heptageniid *Cinygma* sp., and the stonefly *Yoraperla* sp. Sensitive taxa comprised 21% of the assemblage. It is likely that water quality was essentially good at the site, despite the low mayfly taxa richness.

"Clinger" taxa richness (8) was lower than expected, but 74% of sampled animals were "clingers". Six caddisfly taxa were present. These findings suggest that fine sediment deposition probably did not appreciably compromise the availability of hard substrate habitats. Other instream habitats appear to have been adequately available, since no fewer than 31 taxa inhabited the site; 10 of these taxa were predators, which rely on diversity of habitats to harbor a diversity of prey. Only 4 semivoltine taxa were collected, but they represented 41% of sampled animals; catastrophes do not seem to have affected life cycles in this reach of Ditch Creek. The functional mix of faunal components appears to be entirely appropriate for an unimpaired montane system.

The assemblage collected at the site on Buck Creek yielded a biotic index value (3.07) slightly higher than expected for an unimpaired montane stream. In addition, the mayfly taxa richness (5) was somewhat lower than expected, and the abundance of midges (35% of sampled organisms) was higher than expected. While these findings may indicate that some impairment to water quality affected the benthic fauna, the high number of sensitive taxa (8) supported at the site seems to suggest otherwise. Sixteen percent of sampled animals were in taxa that exhibit intolerance to water quality disturbances. These included the stonefly *Visoka cataractae* and the mayfly *Cinygma* sp. Water quality was likely unimpaired at this site, and temperatures appear to have been cold.

Habitat indicators all suggest that reach-scale and small-scale features were intact here. Five stonefly taxa were collected; high stonefly taxa richness may be associated with riparian zone integrity, unaltered channel morphology, and streambank stability. Eleven "clinger" taxa and 8 caddisfly taxa imply the lack of fine sediment impact to hard substrate surfaces. Other instream habitats were likely abundant and available as well, since the site supported a large number of taxa (32) and an ample representation of predators (13% of sampled animals in 9 taxa). Significantly, only 2 long-lived taxa were collected; these made up 12% of sampled animals. While catastrophes such as dewatering seem to have been unlikely because of the diversity of taxa and the abundance of semivoltine animals, the possibility that recent life cycle limiting events took place (and so may account for the low number of long-lived taxa) cannot be ruled out. The functional composition contained all expected elements; proportions of the various functional groups appeared to be appropriate.

The upper site on Nez Perce Creek (UNez1) supported a balanced, sensitive, cold-stenothermic assemblage characteristic of unimpaired montane streams. High mayfly taxa richness (9) at the site, coupled with a very low biotic index value (1.40) strongly suggest that water quality here was excellent. The site supported no fewer than 14 cold water taxa; and 15 taxa were exquisitely sensitive to both water quality and habitat perturbations. Intolerant taxa collected here included the caddisflies *Neothremma* sp., *Cryptochia* sp., and *Anagapetus* sp.; these are taxa typically associated with the least impaired of montane stream sites. The preponderance of evidence implies that cold, clean water provided a pristine matrix for aquatic life at this site.

Twenty "clinger" taxa and a rich caddisfly fauna (11 taxa) suggest that fine sediment deposition was probably non-existent here. High taxa richness (44) and a very large proportion of predators (29% of collected animals) in 13 different taxa give credibility to the notion that instream habitats were intact and diverse. Eight stonefly taxa were collected; richness in this group may be an indication of intact and functional reach-scale habitat features. It seems unlikely that dewatering or other disasters recently occurred in this reach, since at least 7 semivoltine taxa were present. All expected functional components were adequately represented in the sample. Notable was the abundance of shredders; these animals suggest that there were large riparian inputs of organic debris and that hydrologic conditions favored retention of such material.

Excellent habitat and water quality appear to have persisted to the middle site on Nez Perce Creek (MNez2), where 10 mayfly taxa were collected. In addition, the biotic index value (2.07) was low; these findings indicate the likelihood that water quality was very good at this site. Cold water temperatures are suggested by 10 cold-stenotherm taxa, including the mayfly *Caudatella hystrix* and the stonefly *Doroneuria* sp.

Fine sediment deposition was probably not a significant habitat impairment; nineteen "clinger" taxa and 7 caddisfly taxa were supported at this site. Reach scale habitat features appear to have been in good functional condition, since stonefly taxa richness (8) was high. Long-lived taxa made up 26% of the sampled assemblage; six taxa in this group were represented. The abundance and richness of long-lived animals indicates that surface flow had not recently been interrupted, nor had any other catastrophes occurred. Thirty-eight taxa in all were represented in the sample, and 16 of these were predators. These findings suggest unimpaired instream habitats of diverse sorts. The functional mix included all expected components, and their individual proportional contributions seemed appropriate to a healthy montane assemblage.

At the lowermost site on Nez Perce Creek (LNez3), good water quality and cold temperatures are suggested by high mayfly taxa richness (7) and the 4 cold-stenotherm taxa present in the sample. The number of cold water taxa was lower than at the other sites, however, and the biotic index value (3.93), the highest calculated for any site in this study, was higher than expected for a pristine montane site. The abundance of tolerant organisms (10% of sampled animals) was also higher than anticipated. These findings suggest that there may be some mild nutrient inputs in this reach. If this is the case, the effects are small, since the reach supports 5 sensitive taxa, including the stoneflies *Pteronarcys californica* and *Cultus* sp., and the mayfly *Epeorus grandis*.

Twenty-one "clinger" taxa and 6 caddisfly taxa were present in the sample, suggesting that hard substrate habitats were essentially unimpaired by fine sediment deposition. Other instream habitats appear to have been abundant and available as well, since the sample comprised 44 taxa, of which 13 were predators. Notable is the presence of the chloroperlid *Paraperla* sp., a denizen of the hyporheic zone. Though only a single specimen was collected, its presence at the site is strong evidence that interstitial habitats were not jeopardized by sediment or embedded substrate. Recent dewatering or other disasters seem unlikely given the 12 semivoltine taxa supported at the site. High stonefly taxa richness suggests undisturbed conditions for reach scale habitat features such as streambanks, riparian zone, and overall channel morphology. The functional assemblage included all expected components. These 3 sampled sites on Nez Perce Creek demonstrate an expected pattern of increasing abundance of

filter-feeding organisms over the longitudinal extent of the stream. At the lowermost site, this group made up 5% of sampled organisms.

East Fork Bitterrroot River drainage

Low biotic index score (2.33) and high mayfly taxa richness (9) are indications of excellent water quality at the upper site on Martin Creek (Mart1). Eight cold stenotherm taxa were present in the sample; overall sensitive taxa richness was 9. These findings constitute strong evidence that cold, clean water provided the matrix for aquatic life at this site. The mildly elevated value for percent contribution of tolerant organisms is somewhat deceptive. Tolerant organisms were represented by a single taxon, *Baetis tricaudatus*, which is categorized with the tolerant group more on the basis of ubiquity than of a demonstrated tolerance to pollution.

Habitat indicators suggest that conditions at this site were essentially unperturbed. Twenty "clingers" and 9 caddisfly taxa were collected; the critical habitats associated with hard benthic substrate were likely uncompromised by appreciable fine sediment deposition. Other habitats appeared to have been amply available, too, since no fewer than 46 taxa were supported at the site; twelve of these taxa were predators. Riparian zone function and other reach scale features seem to have been intact, since 7 stonefly taxa were present in the sample. Four long-lived taxa (22% of sampled animals) provided evidence that dewatering or other catastrophes had not recently occurred here. Functionally, the assemblage lacked scrapers, which is not unexpected for a montane site, particularly if riparian shading precludes the growth of benthic algal films.

Good water quality apparently persisted at the lower sampled site on Martin Creek (Mart2). The biotic index value (2.76), mayfly taxa richness (8), and number of cold stenotherm taxa (5) confirm that pollutants or warm temperatures did not limit biotic health at this site. Sensitive taxa taken in the collection included *Baetis bicaudatus*, *Zapada columbiana*, and *Doroneuria* sp.

Numbers of both "clinger" taxa (10) and caddisfly taxa (4) were lower than expected for a pristine mountain stream, suggesting that fine sediment deposition may have limited the availability of stony substrates for colonization. Other possible causes of low richness in these groups might include unstable substrates, scouring flow conditions, or infestation by filamentous algae. Taxa richness was also lower than any of the other sites in this study, and although 9 predator taxa were present, the group constituted a smaller proportion of the functional mix than anticipated. These findings suggest that instream habitats were limited or monotonous. The rich stonefly fauna (7 taxa) is likely associated with undisturbed reach scale habitat features such as riparian zone function, streambank integrity, and natural channel morphology. Seven long-lived taxa, including the perlid stoneflies *Hesperoperla pacifica* and *Doroneuria* sp., made up 28% of the sampled assemblage. It seems unlikely that any life-cycle limiting disasters were recent occurrences in this reach. The functional composition of the benthic assemblage lacked predators and scrapers. A paucity of scrapers is not unexpected in highly shaded montane systems.

The upper site on Meadow Creek (Mead1) yielded the lowest biotic index value (0.75) of any site in this study, suggesting that high water quality characterized the site. Mayfly taxa richness (10) was very high, and among the collected taxa were 15 sensitive cold stenotherms. Sixty-four percent of sampled organisms were in this group. Cold water, unpolluted by nutrients or other contaminants, appears to have characterized this site.

High stonefly richness (7 taxa) may be associated with intact reach scale habitat features. Instream habitats seem also to have been unaffected by significant human disturbance, since 21 "clinger" taxa and 10 caddisfly taxa were supported at the site. These findings imply that benthic substrates were free of fine sediment deposition. Other habitats appear to have been abundantly available, since at least 40 taxa were present at the site; fourteen of these taxa were predators, and the proportion of predators in the functional mix was astonishingly high (43%). Among the predatory taxa were the caddisfly *Parapsyche elsis*, and the sensitive mayfly *Drunella spinifera*. Other expected functional components were present as well; the proportion of scrapers was low (7%), but low numbers of scrapers is not

unusual in shady montane stream environs. Semivoltine taxa were abundantly represented (15% of the assemblage) and many taxa (16) in this group were collected, making it likely that dewatering or toxic inputs limited long-lives recently.

The lower site on Meadow Creek (Mead2) supported a rich, sensitive, and diverse fauna characteristic of near-pristine streams in the montane regions. The low biotic index value (2.78) and high mayfly richness (9 taxa) suggest clean water, and the presence of 6 cold water taxa suggests low water temperatures.

Seventeen "clinger" taxa and 7 caddisfly taxa were collected; these groups require stable stony substrates free of fine sediment deposition. Other indicators of instream habitat condition and availability also yielded positive results; high taxa (42) and predator (14) richness indicate a diversity of occupied niches. Reach-scale habitat appears to have been in excellent condition; among the 7 stonefly taxa in the sample were capniids, and the sensitive perlid *Doroneuria* sp. Catastrophic dewatering or other impacts apparently did not recently limit the long life cycles of the semivoltine taxa, since 4 such taxa were present and among them this group accounted for 43% of the sampled assemblage. Shredders were underrepresented in the functional mix; this could be associated with a dearth of riparian inputs of large organic debris, or with hydrologic conditions that did not favor the retention of such material. Other expected functional components were present.

Low biotic index value (2.46) and high mayfly taxa richness (11) suggest that water quality was excellent at the upper sampled site on Reimel Creek (Reim1). No fewer than 11 sensitive cold-stenotherm taxa, including the mayflies *Caudatella hystrix* and Drunella doddsi and the stonefly *Megarcys* sp. were collected. It appears likely that cold, clean water was a characteristic of the site.

Habitat indicators suggested undisrupted habitat on both large and small scales. Twenty-one "clinger" taxa and 8 caddisfly taxa were represented in the sample; these groups are associated with hard substrates clean of fine substrate deposition. High taxa richness (44) and a large representation of predators (12 taxa) suggest that instream habitats were complex. Six stonefly taxa were present at the site; this kind of diversity among the stoneflies may be associated with near-pristine reach-scale habitat features. Such features could include riparian zone integrity, streambank stability, and natural channel morphology. Long-lived taxa were amply represented (16% of animals, 6 taxa), implying that year-round surface flow had probably not been recently interrupted by dewatering, nor had other catastrophic life-cycle limiting events occurred. All expected functional components of a montane assemblage were present in suitable proportions.

The lower site on Reimel Creek (Reim2) exhibited similar evidence of high quality, cold water. The biotic index value was 2.02, and 9 mayfly taxa were collected at the site. Cold stenotherms accounted for 12% of the sampled assemblage; eight taxa were represented in this group. Sensitive cold water animals included the peltoperlid stonefly *Yoraperla* sp., and several ephemerellid mayflies.

Nineteen "clinger" taxa and a rich caddisfly fauna (8 taxa) suggest that fine sediment deposition was probably not significant here. High taxa richness (38) and 8 predator taxa suggest that instream habitats were intact and diverse. Six stonefly taxa were collected; richness in this group may be an indication of intact and functional reach-scale habitat features. It seems unlikely that dewatering or other disasters recently occurred in this reach, since 7 semivoltine taxa were present in the sample. All expected functional components were adequately represented in the sample. The proportional contribution of filter-feeders to the functional mix was higher at this site than at any other in the study. This suggests that fine particulate organic material in suspension was an important energy source for the biota here.

CONCLUSIONS

- Nearly all of the West Fork and East Fork Bitterroot River sites sampled for this study produced taxonomic and metric evidence for undisturbed instream and

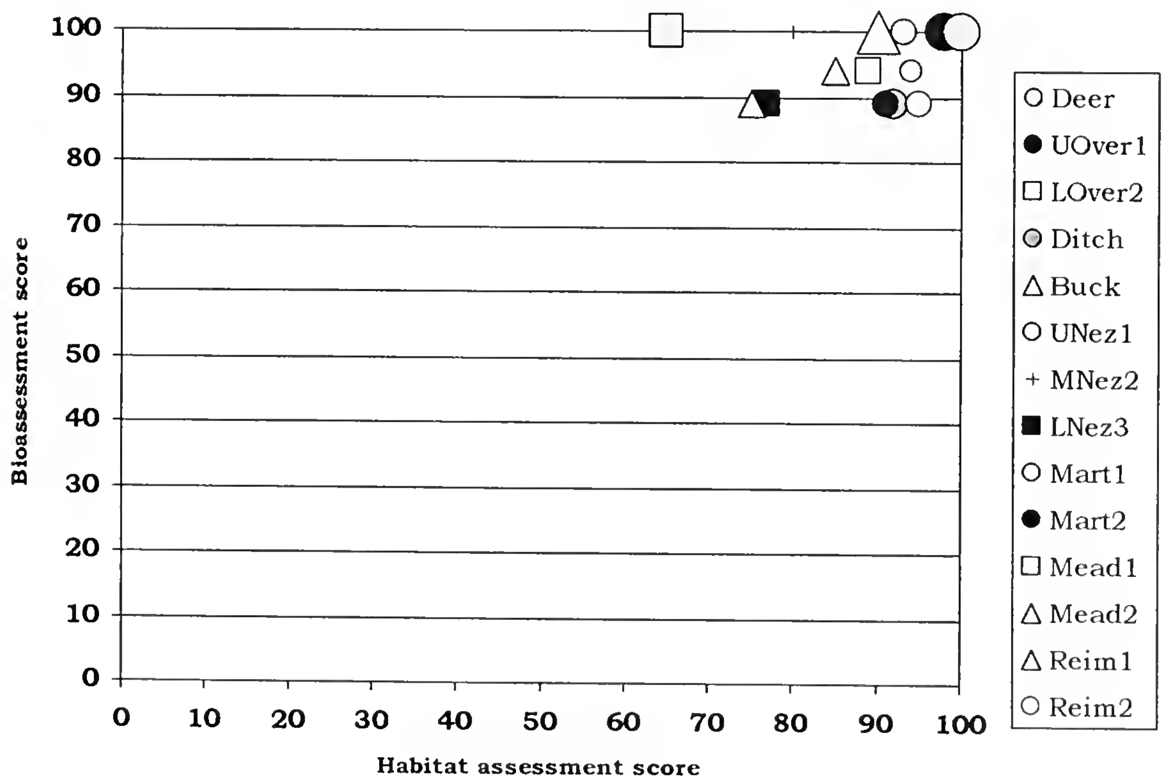
reach scale habitat conditions. Water quality was excellent at most of the sites in the study.

- Evidence for very mild water quality perturbance was apparent at the lowest sampled site on Nez Perce Creek (LNez3), where slight nutrient enrichment may have been the cause of the slightly elevated biotic index value, and the higher-than-expected abundance of tolerant organisms.

- Low "clinger" and caddisfly richness at the lower site on Martin Creek (Mart2) may indicate that fine sediment deposition affects the benthic assemblage to some degree in that reach.

- Figure 3 illustrates the relationship between habitat assessment scores and bioassessment scores for the 14 sites in this study. In the graph, all of the symbols fall in the area of the graph that is predicted to indicate excellent water quality combined with undisturbed habitat.

Figure 3. Total bioassessment scores plotted against habitat assessment scores for sites in the West and East Fork drainages of the Bitterroot River, October 2002.



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